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DRAWINGS ATTACHED

1184,315

filing Complete 28135/68) and Date of Application (No. Specification: 13 June, 1968. Application made in United States of America (No. 651,906) on 7 July, 1967.

Complete Specification Published: 11 March, 1970

Index at acceptance: -B7 G(49B2B, 49B2C, 49D1G, 49D1J2)

International Classification: -B 64 c 15/08

## Jet Propulsion Engine Nozzle

COMPLETE SPECIFICATION

CORPORATION, a States of America (Assignees of CHARLES HOBART SMALE) do hereby declare the invention for which we pray that a patent may be granted to us and the method by which it is to be performed, to be particularly described in Company incorporated under the laws of the America, of Grand Boulevard, in the City of Detroit, State of Michigan, in the United State of Delaware, in the United States of GENERAL MOTORS

and by the following statement: —
This invention relates to jet propulsion engine nozzles capable of vectoring, by which meant jet nozzles capable of varying the direction of a propulsive or lift jet.

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The preferred embodiment of the invention is intended for application to lift engines in the nozzle may be actuated to deflect the jet either forward or backward or to either side for manoeuvring the aircraft or to control airwhich the axis of the engine is vertical and craft jaw. 8

Preferably, the nozzle is of a convergent type, but it is applicable to divergent nozzles and to nozzles for engines for purpose other than direct lift.

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The principal object of the invention is to improve the performance of vertical lift engines. Another object is to render available a simple easily controlled nozzle vectorable The scope of the invention is defined by about two crossed axes.

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filling the space

material

noneycomb

of a be performed is particularly described below with reference to the accompanying drawings, the appended claims; how the invention may Figure il is a partial elevation view in which: –

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lift jet engine including a deflecting nozzle according to the invention;

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gure 3 is an elevation view corresponding Figure 1 with the nozzle operated to deflect Figure 2 is a bottom view of the same; the jet to provide forward thrust; 2

Figure 4 is a view on a plane at right angles

to that of Figure 3 showing the nozzle deflected to provide lateral thrust

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taken on the plane indicated by the line 5-5 in Figure 4 showing the inter-connection between the main and corner leaves; and Figure 5 is a fragmentary sectional view

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2 15 extending from each leaf 111 is coupled to 6 the piston rod 17 of an actuating cylinder 18 suitably anchored by means (not illustrated) to the engine so that the flap 11 may be swung inwardly or outwardly by the cylinder 18. Each main flap is coupled to an individual 7 Figure 6 is an oblique view of the nozzle.

Referring first to Figures !! and 6, the jet deflecting nozzle is shown as attached to the in a rectangular outlet 10 which is preferably square. Four main jet deflecting flaps ill are mounted at the end of the jet pipe, one at gine. A jet pipe 9 provides a transition from lower or exhaust end of a reaction engine E, which may be a lift turbojet or turbofan encircular to rectangular section and terminates actuating cylinder. The flaps ill are of a light weight cellular double-walled construction, as by hinges 13. The flaps are of trapezoidal form, having edges 114 converging in the direction away from the hinge. An actuating arm Ilustrated in Figure 5, comprising an outer sheet 119, an inner sheet 20, and cellular or each side, the flaps being pivotably mounted

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which has an opening universally connected to There is, of course, a wide gap between the four corner closure members 24, one at each member comprising two corner flaps 25 connected by a corner hinge 26. Each corner hinge includes a hinge pin terminating in a head 27 sure of the rectangular nozzle is completed by corner of the nozzle, each corner closure edges 114 of adjacent main leaves. The enclothe jet pipe 9 by a ball-headed stud 29 extendface of the main between and bonded to the sheets. the

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prising outer and inner sheets and a honey-The corner flaps are coupled to the main walled structure as shown in Figure 5, comthe side edges of the main flaps 111. Like the the corner flaps are of doublecomb bridging the space between the sheets.

ocurer flaps may take place with a minimum of friction. The corner flap is made in two parts, an upper and a lower part, which are joined together by an arcuste track piece 35 joined together by an arcuste track piece 35 itfleures 1 and 5) strengthened by gussets or stiffeners 36. The track piece has double fallanged edge portions 37 and 38, the two portion of the track piece forms a track 39 which receives a roller 41 rotatably mounted on a boss 42 extending from the main flap 1.1. The track piece also forms a second track 43 which co-operates with two rollers 44 rotatably mounted on angled bosses 45 extending from the main flap !1. The rollers are in position to engage both faces of the tracks, which extend on both sides of the rollers; thus a restraint is provided between the main and corner flaps in both the direction axially of flanges of which are welded or brazed to the outer and inner walls of the corner flap. One an axis at each upper corner of the main flap The main and corner flaps are connected by rollers operating in tracks on the corner flaps so that this extension and retraction of the flaps so as to allow the former, to pivot about perpendicular to the plane of the main flap. the nozzle and that radially of the nozzle. 2 8 ಜ 2 2

motion to provide forward thrust on the airframe in addition to the lift. Pigure 4 is a hand main flap has been moved toward the nozzle axis and the left-hand main flap away from the axis, so that the engine thrust has The mode of operation of the nozzle should be clear but will be described briefly. As shown in Figures 1 and 2, the nozzle is in what may be considered the normal slightly convergent centered configuration, with no deflection of the jet. The angle of all of flaps 11 to the axis of the nozzle is the same. In Figure 3, rear view of the engine in which the rightsubstantial component to the left for movement of the aircraft to the right, or yawing which is a side view, the forward main slap 11 has been deflected rearwardly and the rear main flap 111 has likewise been deflected rearzle with a substantial rearward component of wardly so that the jet will issue from the nozof the aircraft by co-operation of two such engines with the thrust oppositely deflected. 55 ည 2 35 9

With the structure shown, it is possible to

putting the throat at the hinge line rather than arrangement of main and corner flaps is adaptable to polygonal nozzles of three or more sides, but a rectangular nozzle is preferred. constant during vectoring, but it can be varied if desired. Any suitable control can be used ferred embodiment as a lift engine nozzle such operation is not contemplated. The structural Preferably, the nozzle outlet area is maintained open the nozzle into a divergent configuration. to co-ordinate the flap actuators as desired. WHAT WE CLAIM IS: the exit of the nozzle.

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Wern's We warm we wern's we have a jet propulsion engine operable to deflect the jet comprising the following combination:—a jet pipe having a pollowing combination:—a jet pipe having a pollowing downstream from a common hinge plane; each side comprising a main flap hinged to one side of the jet pipe at the said plane; the main flaps being of trapezoidal form with each and a corner flap at each said edge the hinge, and a corner flap at each said edge of each main flap extending substantially in of each main flap extending substantially in there being actuator means effective to pivot cach main flap about its hinge axis. sponding main flap for pivoting about an axis perpendicular to the main flap at the adjacent end of the hinged side of the leaf and mainend of the hinged side of the leaf and mainsponding main leaf; and a hinged connection between the two corner flaps at each corner bounding sides pivotable to deflect the jet and the plane of the corresponding main flap; a taining the corner leaf parallel to the corredefined by the bounding sides of the jet pipe outlet; the main and corner flaps thus forming nozzle of polygonal cross section with all connection of each corner flap to the corre-

3. A nozzle as recited in claim 1 in which the connection of each corner flap to the main sap comprises track means on one sap and 2. A nozzle as recited in claim it in which roller means on the other flap engaging the the nozzle is rectangular. track means.

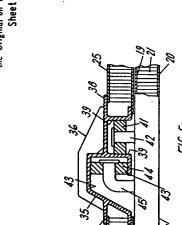
track; one track and roller set having the roller 4. A nozzle as recited in claim 3 in which the track means includes two tracks and the axis at right angles to that of the other set. roller means includes rollers engaging

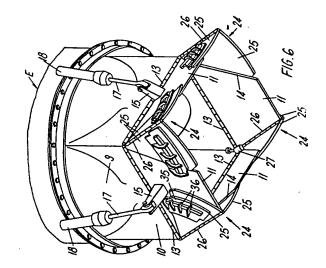
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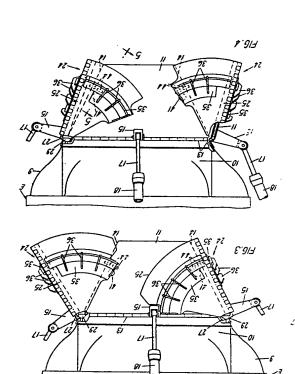
5. A jet propulsion engine nozzle, substantially as hereinbefore particularly described with reference to, and as shown in, the accompanying drawings.

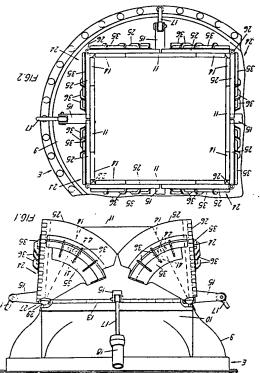
Chartered Patent 'Agent

Printed for Her Majesty's Stationery Office by the Courier Press, Leamington Sps. 1970. Published by the Patent Office, 25 Southampton Buildings, London, W.C.2, from which copies may be obtained.









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Sheet COMPLETE SPICIFICATION 1184312